M99/420/H(3)M

INTERNATIONAL BACCALAUREATE
BACCALAURÉAT INTERNATIONAL -
BACHILLERATO INTERNACIONAL

MARKSCHEME

May 1999

CHEMISTRY

Higher Level

Paper 3

19 pages

OPTION C – HUMAN BIOCHEMISTRY

C1. (a) Coconut oil *[1 mark]*

The more unsaturated the oil, the bigger the iodine index (or converse). *[1 mark]*

(b) M_R of oleic acid: $[(18\times12.0)+34.0+(16.0\times2)]=$ **282.0** *[1 mark]*

M_R of iodine: $126.9\times2=$ **253.8** *[1 mark]*

$$\text{Iodine Index} = \frac{100.0\times253.8}{282.0} = 90$$ *[1 mark]*

(c) Olive oil *[1 mark]*

highest degree of unsaturation/**most** unsaturated/**highest** iodine index *[1 mark]*

(d) In order to **maintain body temperature/insulation** *[1 mark]*

Energy source : or to protect organs *[1 mark]*

Cell membranes to carry fat soluble vitamins *[1 mark]*

to prevent skin drying/waterproofing

Total [10 marks]

C2. (a) V_{max} ; maximum reaction rate. *[1 mark]*

(b) 0–X: free active sites can accommodate increase in [subs] *[1 mark]*

Thereafter: enzyme molecules are saturated with substrate/all active sites in use (so, they cannot act faster). *[1 mark]*

(c) K_m represents [subs] at which the reaction rate is $\frac{1}{2}V_{max}$. *[1 mark]*

The higher the value of K_m, the lower the activity of the enzyme.

OR

The lower the value of K_m, the higher the activity of the enzyme

OR

$K_m \propto \frac{1}{\text{activity}}$ of enzyme *any one of these three answers [1 mark]*

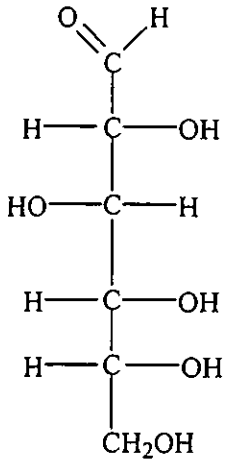
(d) ~ 3 μmol dm^{-3} *[1 mark]*

accept between 2 and 4 (must give units for mark)

Total [6 marks]

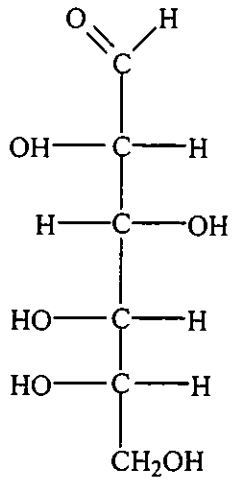
C3. (a) CH_2O or $(CH_2O)_n$
Carbonyl/ C=O also aldehyde (alkanal)
Hydroxyl/OH *[3 marks]*

(b)



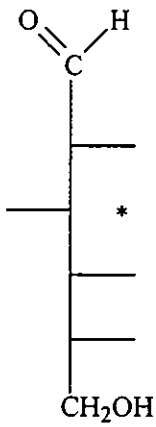
(D-glucose)

OR

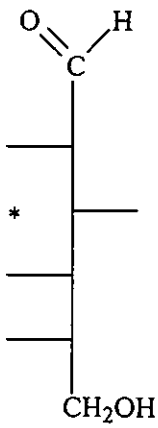


(L-glucose)

OR



(D-glucose)



(L-glucose)

must show 2nd or 3rd OH is in a different direction from the other OH groups.* *[1 mark]*

In one isomer, the OH group on the C_1 carbon is in a different direction from that in the other isomer **or** shown by two correctly drawn ring structures. *[1 mark]*

Optical isomerism/anomerism/stereoisomerism. *[1 mark]*

(c) $C_6H_{12}O_6 + C_6H_{12}O_6 \rightarrow C_{12}H_{22}O_{11} + H_2O$
OR $2C_6H_{12}O_6 \rightarrow C_{12}H_{22}O_{11} + H_2O$ *[2 marks]*
(*i.e. 1 mark* for $C_{12}H_{22}O_{11}$ and *1 mark* for balancing)

Many monomers / monosaccharide molecules are involved } *[1 mark]*
OR Many C – O – C bonds formed }

Total [9 marks]

OPTION D – ENVIRONMENTAL CHEMISTRY

D1. (a) $O_2 + (h\nu) \rightarrow 2O$ *[1 mark]*

$O + O_2 \rightarrow O_3$ *[1 mark]*

$O_3 \rightarrow O_2 + O$ or $O + O_3 \rightarrow 2O_2$ } do **not** give mark for $2O_3 \rightarrow 3O_2$ *[1 mark]*

shorter λ for (more) ozone formation (or converse) *[1 mark]*

shorter λ is higher energy (or converse) *[1 mark]*

(b) $CCl_2F_2 \rightarrow CClF_2\bullet + Cl\bullet$ *[1 mark]*

$O_3 + Cl\bullet \rightarrow ClO\bullet + O_2$ *[1 mark]*

$ClO\bullet + O \rightarrow O_2 + Cl\bullet$ *[1 mark]*

(c) Catalysis on ice particles (surface). *[1 mark]*

Total [9 marks]

D2. (a) $CO_2(aq) + H_2O \rightleftharpoons H_2CO_3(aq)$ ***[1 mark]***, it forms an acid (***[1 mark]***)

OR

$CO_2 + H_2O \rightleftharpoons H^+(aq) + HCO_3^-(aq)$ ***[2 marks]*** as H^+ implies acidic

[2 marks]

(b) HNO_3 **and** H_2SO_4 / H_2SO_3 *[2 marks]*

[1] [1]

NO – automobiles (some reaction between nitrogen and air) *[1 mark]*

(Subsequent reaction of the NO with oxygen to produce NO_2 and reaction of NO_2 with water.)

SO_2 – smelters in the production of copper/power plants burning coal or oil (containing sulphur)/volcanoes *[1 mark]*

equation for production of acid (any of the three acids) *[1 mark]*

(c) Leaching minerals from the soil
Fishless lakes
Damaging stone buildings
Damaging trees/forests
Iron/steel objects rust more quickly
Poorer health

*any two **[1 mark]** (accept valid alternatives)* *[1 mark]*

Total [8 marks]

D3. Give ***[1 mark]*** for process and ***[1 mark]*** for what is removed

Primary:	filtration sedimentation flocculation	mostly insoluble material

any one method ***[2 marks]***

Secondary: activated (bacterial) sludge — oxidisable waste (organic products) ***[2 marks]***

Tertiary:	reverse osmosis electrodialysis **chemical** precipitation ion exchange	soluble materials (NO_3^-, detergents)

any one method ***[2 marks]***

Due to greater levels of:
NO_3^-/fertilisers
PO_4^{3-}/detergents

any one by name, formula or source ***[1 mark]***

reverse osmosis: semipermeable membrane and high pressure

electrodialysis: electrodes/cells and semipermeable membranes

chemical precipitation: chemical added combines with dissolved ions to give a precipitate (*e.g.* urea for nitrate)

ion exchange: unwanted ion is exchanged for a harmless ion

Also accept algae ponds and carbon beds.

any one ***[1 mark]***

Total [8 marks]

OPTION E – CHEMICAL INDUSTRIES

E1. (a) (i) (Alumina has a very high melting point. By dissolving the alumina in cryolite) the electrolysis can be carried out at a much lower temperature/lowers melting point of alumina. ***[1 mark]***

(ii) $2O^{2-} - 4e^- \rightarrow O_2$ or the 'half' version $O^{2-} - 2e^- \rightarrow \frac{1}{2}O_2$ ***[1 mark]***

(iii) Oxygen produced at the anode reacts with the carbon electrode / Carbon (anode) burns in O_2 formed. *Must give* $C + O_2 \rightarrow CO_2$ *for the mark.* ***[1 mark]***

(b) (Alumina) reacts/dissolves with/in NaOH/KOH ***[1 mark]***
impurities/oxides do not react/dissolve ***[1 mark]***
Basic (must be included for the mark)

(c) Examples could include:
resistance to corrosion – window frames
electrical conductivity **and** low density – overhead power cables
low density – aircraft (fuselage) N.B. *link* between property and use essential

accept valid alternatives, e.g. good heat conductor – saucepans (cooking)
any two, ***[1 mark]*** *each* ***[2 marks]***

(d) lower cost in energy terms/expensive to produce
conserve resources

accept other valid reasons ***[2 marks]***

Total [9 marks]

E2. (a)

$(RCOO)_2$	$\rightarrow$	$(2RCOO\bullet) \rightarrow 2R\bullet + 2CO_2$	***[1 mark]***
$R\bullet + C_2H_4$	$\rightarrow$	$RCH_2CH_2\bullet$	***[1 mark]***
$RCH_2CH_2\bullet + C_2H_4$	$\rightarrow$	$RCH_2CH_2CH_2CH_2\bullet$	***[1 mark]***
$RCH_2CH_2CH_2CH_2\bullet + R\bullet \rightarrow$		$R(CH_2)_4R$	***[1 mark]***

If just states "initiation, propagation, termination", award ***[1 mark]***

Catalyst ***[1 mark]***
Ziegler ***[1 mark]***
Lower pressure/lower temperature ***[1 mark]*** ***[3 marks]***

(b) Not free radical/addition ***[1 mark]***
Monomers must contain two functional groups/small molecule (*e.g.* water) eliminated. ***[1 mark]*** ***[2 marks]***

Total [9 marks]

E3. (a) Named fuel *e.g.* **propane** ***[1 mark]***
Accept any named hydrocarbon

balanced equation (*e.g.* $C_3H_8 + 5O_2 \rightarrow 3CO_2 + 4H_2O$) ***[1 mark]***

(b) Balanced equation showing production of appropriate alkane and alkene
(*e.g.* $C_{10}H_{22} \rightarrow C_8H_{18} + C_2H_4$) ***[2 marks]***

if only give alkane/alkene, ***[1 mark]***

(c) Stage 1: **Fractional distillation** ***[1 mark]***
Stage 2: Ethene is produced by **cracking** less valuable fractions ***[1 mark]***
Stage 3: **Polymerisation** is used to convert ethene into polythene ***[1 mark]***

Total [7 marks]

OPTION F – FUELS AND ENERGY

F1. (a) $2C(s) + O_2(g) \rightarrow 2CO(g)$

OR

$S(s) + O_2(g) \rightarrow SO_2(g)$

not $NO_2(g)$ ***[1 mark]***

(b) CO ensure efficient combustion (by monitoring combustion conditions and products)/ensuring excess air/oxygen

SO_2 (scrubbing the gas) by passing through an alkali/absorb in (slurry) powdered limestone – water/desulphurised coal OR fluid bed combustion.

not just scrubbing

NO_2 *if given in B* – (scrubbing the gas) by passing through an alkali

not just scrubbing

any one, ***[1 mark]*** ***[1 mark]***

(c) can be pumped
easy to burn/easy to mix with air/easier to control rate of combustion

any two ***[2 marks]***

(d) (i) $2CH_3OH + 3O_2 \rightarrow 2CO_2 + 4H_2O$ ***[1 mark]***

(ii) ΔH_f^0 (from Data Booklet) – 239 ($kJ\,mol^{-1}$) ***[1 mark]***
(Using $CH_3OH + 1\frac{1}{2}O_2 \rightarrow CO_2 + H_2O$)
$\Delta H = H^0_{products} - H^0_{reactants}$ ***[1 mark]***
$= -(1 \times 393.5) - (2 \times 258.8) + (1 \times 239)$ ***[1 mark]***
$= -672.1$ ($kJ\,mol^{-1}$) *accept –672 $kJ\,mol^{-1}$ (units must be included). If value for 2 moles given (–1344.2) give maximum of* ***[3 marks]***. ***[1 mark]***

correct answer scores ***[4 marks]***
(N.B. last *3 marks* could be obtained even with incorrect Data Booklet use *i.e.* last *3 marks* consequential on **their** ΔH_f^0 value)

(iii) lower/less negative/more positive ***[1 mark]***
Energy needed to vapourise/evaporate the water/steam not condensed, therefore less energy released ***[1 mark]***

Total [11 marks]

F2. (a) Chemical (*which may be implicit*) rearrangement of outer electrons/no new elements or atoms formed.
(Nuclear – again may be implicit, *i.e.* order in question) change in nucleus emphasis/new elements/atoms formed/(outer) electron arrangement unchanged

[1 mark]

(b)

shielding	–	to prevent escape of nuclear particles/radioactivity
control rods	–	to control and maintain a safe level of fission/control number of free neutrons
cooling system	–	maintain temperature of reactor (core)
moderator	–	to slow the neutrons

[2 marks] *each*

[6 marks]

In the **absence** of **any** role being assigned give *2 marks* for three components (*1 mark* for two components)

Total [7 marks]

F3. (a) (i) (fast) electron
Sulphur

[2 marks]

(ii) 5 half-lives
5×14
$= 70$ **days**

[3 marks]

(b)
- Surround wastes with concrete or other suitable material
- Solidify wastes, encapsulating them in glass or ceramic, then bury.
- Bury the wastes in an underground hole so that the wastes eventually melt and fuse with surrounding rock into a glassy ball
- Encase wastes in well-designed containers and drop them into the ocean
- Change harmful isotopes into harmless ones by using high-level neutron bombardment, lasers, or nuclear fusion

any two of the above, OR valid alternatives, ***[1 mark]*** *each.*

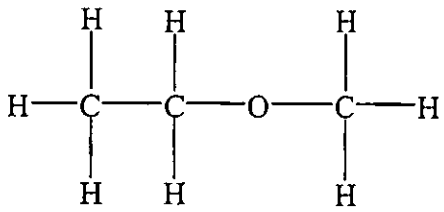
[2 marks]

(N.B. searching for the principles)

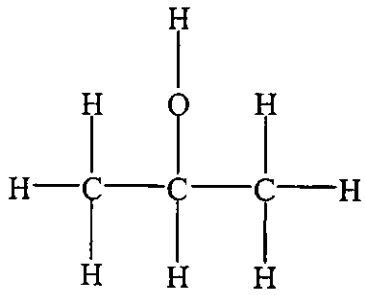
Total [7 marks]

OPTION G – MODERN ANALYTICAL CHEMISTRY

G1. (a)



A



B

[2 marks]

(correct structural formulae but **incorrect** labelling deduct *1 mark*).
In absence of 'labelling' assume order is as in question.

(b) (i) Peaks in (intensity) ratio of **3:3:2**.
The chemical shifts of these hydrogens will be near **3.8 ppm**.
Any correct reference to splitting pattern, *e.g.* (smallest area peak) split into quartet/one peak (with greatest area) split into a triplet *[3 marks]*

(ii) Peaks in (intensity) ratio of **6:1:1**.
The peak corresponding to the **most Hs will be split into a doublet**/one of the smallest area peaks will be a singlet/the other a septet *(accept complicated pattern)*.
The O–H hydrogen will normally have a chemical shift at **4.5 ppm** *[3 marks]*

(c) (i) No mark for just yes or no only. If YES, give ***[1 mark]*** for pointing out spectra are different. Award ***[3 marks]*** for a reasonable argument. If NO, give ***[1 mark]*** for pointing out spectra contain many similar peaks, *e.g.* 15, 29, 59. Only give further marks for thorough justification. *[3 marks]*

(ii) ***[1 mark]*** for B (alkanol) having a higher boiling point. Give 2nd mark for hydrogen bonding in alkanols. *[2 marks]*

Total [13 marks]

G2 (a) Vibrations (or stretching/bending) *[1 mark]*
Change in dipole moment is required *[1 mark]*
Different functional groups in different regions *[1 mark]*
Precise absorption affected by neighbouring atoms (or mention of fingerprint region). *[1 mark]*

(b) (i) ethanoic acid:

C=O	1680–1750
O–H	2500–3300/3580–3650
C–H	2840–3095

Any two correct for both marks *[2 marks]*

(ii) methyl methanoate:

C=O	1680–1750	
C–H	2840–3095	
C–O	1000–1300	*any two,* ***[1 mark]*** *each*

[2 marks]

(c) O–H in ethanoic acid could be used/also C–O peak in ester could be used *[1 mark]*
Other peaks/absorptions occur in both spectra *[1 mark]*

(d) O–H *[1 mark]*

$\frac{1}{3300}\ \text{cm}^{-1} = 3.03\times10^{-4}\ \text{cm}$ *[1 mark]*

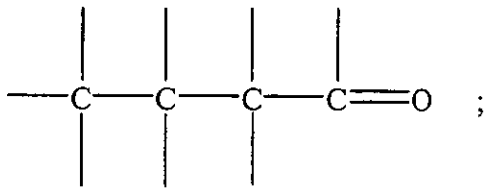
If 'free' OH is ***not*** *in the list, maximum energy will occur for C–H*
$\frac{1}{2480}\ cm^{-1} = 4.03\times10^{-4}\ cm$ *(****2 marks*** *then possible)*

If free OH ***is*** *in the list* ***1 mark*** *possible for* λ *C–H* $= 4.03\times10^{-4}$ *cm, i.e.* ***wrong*** *choice in (c) but converted correctly to* λ *value*

Total [12 marks]

OPTION H – FURTHER ORGANIC CHEMISTRY

H1. (a) carbonyl, C=O *(both needed)* ***[1 mark]*** *(accept alkanol/alkanone)*



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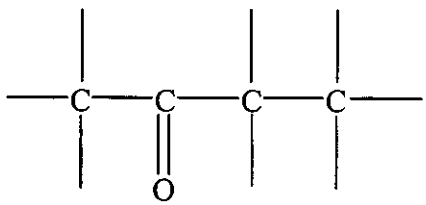

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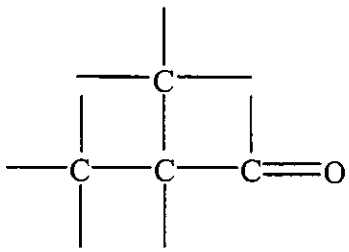
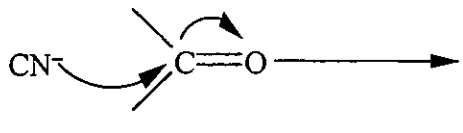
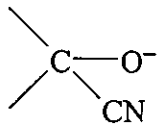
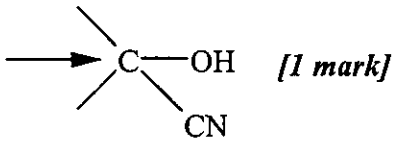


All three: [2 marks]. *One/two:* ***[1 mark].*** *Penalise extra structures once.* ***[3 marks]***

(b) (i) 

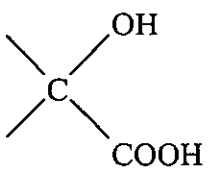


CN^- shown as attacking species ***[1 mark]*** ***[1 mark]***



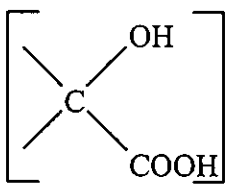
[1 mark]

[3 marks]

(ii) 

[1 mark]

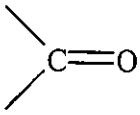
chiral C yet racemic mixture or words to that effect ***[1 mark]***

again, only interested in the 

for the first mark ***[2 marks]***

continued...

Question H1. continued

N.B. Throughout (b)(i) and (b)(ii) only interested in  *part of molecule.*

Whatever else may be attached to the carbonyl carbon may be ignored.

Total [8 marks]

H2. (a) $C_2H_6 + Br_2 \rightarrow C_2H_5Br + HBr$ ***[1 mark]***

Sunlight/UV light ***[1 mark]***

$C_2H_4 + Br_2 \rightarrow C_2H_4Br_2$ ***[1 mark]***

Room temperature/bromine solution ***[1 mark]***

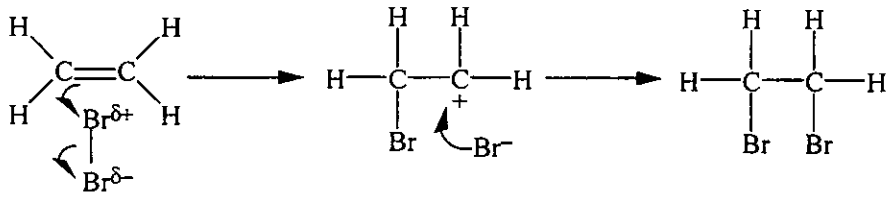
Either

$Br_2 \rightarrow 2Br\bullet$ ***[1 mark]***

$C_2H_6 + Br\bullet \rightarrow C_2H_5\bullet + HBr$ ***[1 mark]***

$C_2H_5\bullet + Br_2 \rightarrow C_2H_5Br + Br\bullet$ ***[1 mark]***

OR



[1 mark] ***[2 marks]*** *i.e.* structure of ion ***[1 mark]***

attack by Br^- ***[1 mark]*** ***[3 marks]***

Total [7 marks]

H3. (a) Bromination: Br_2 and $AlBr_3$ **or** $FeBr_3$/reflux. **Must** include halogen carrier for mark. ***[1 mark]***

$Br_2 + AlBr_3 \rightarrow AlBr_4^- + Br^+$ ***[2 marks]***

OR $Br_2 + FeBr_3 \rightarrow FeBr_4^- + Br^+$ *

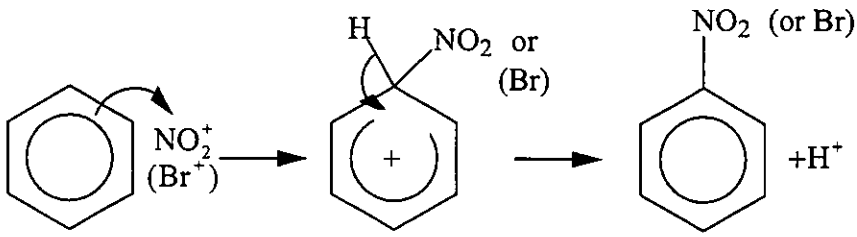
** correct electrophile Br^+ [1 mark]; correct balanced equation [1 mark]*

Nitration: Concentrated acids/heat ***[1 mark]***

$H_2SO_4 + HNO_3 \rightarrow HSO_4^- + NO_2^+ + H_2O$ * ***[2 marks]***

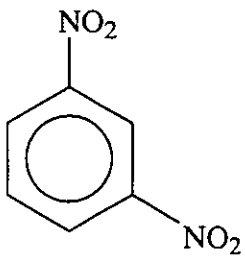
** correct electrophile NO_2^+ [1 mark]; correct balanced equation [1 mark]*

(b)



[1 mark] ***[1 mark]*** ***[2 marks]***

(c)



*(Award **[1 mark]** for structure, **[1 mark]** for explanation in terms of stability of intermediate(s) etc. [– NO_2 is 3-diverting on its own no marks].* ***[1 mark]***

comment on directing influence (*e.g.* first NO_2 group e-withdrawing and deactivating, withdrawing e-density from 2 and 4 positions, so NO_2 group enters position 3). Remember **some** comment **with some** explanation expected, even NO_2 is 'meta' directing. ***[1 mark]***

Total [10 marks]